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Art. XII.—*On the Jyotisha Observation of the Place of the Colures, and the Date derivable from it.* By William D. Whitney, Esq., Professor of Sanskrit in Yale College, New Haven, U.S. Communicated by F. Hall, Esq.

[Read July 4, 1864.]

Colebrooke, in his celebrated essay "On the Vedas, or Sacred Writings of the Hindus" (As. Researches, vol. viii.; Misc. Essays, vol. i.), was the first to direct general attention to the now familiarly known passage of the Jyotisha relative to the position of the solstices in the Hindu lunar zodiac, and to derive from it a date for use in determining the doubtful chronology of the earliest period of literary productiveness in India. His conclusion is expressed as follows: "Hence it is clear, that Dhanishṭhâ and Âśleshâ are the constellations meant; and that, when this Hindu calendar was regulated, the solstitial points were reckoned to be at the beginning of the one, and in the middle of the other: and such was the situation of those cardinal points in the fourteenth century before the Christian era" (Misc. Essays, vol. i., pp. 109-110). He had a little before (ibid., p. 106) declared that he "inclined to think, that the ceremonies called *yajña*, and the prayers to be recited at those ceremonies [namely, the prayers constituting the *sanhitâs* of the three older Vedas], are as old as the calendar."

Hardly any datum has been so often referred to, and so much relied on, as this, by those engaged in the investigation of Indian antiquity. It has been in nearly the same degree the sheet-anchor of the prevailing chronology of the Vedic period, as the identification of Sandrocottus and Chandragupta has been of that of the middle ages of Indian history. Within a few years, however, more than one voice has been raised to deny the accuracy of Colebrooke's calculation, and to impugn the validity of the chronological conclusion which he derived from it. The eminent mathematician, Archdeacon Pratt of Calcutta, in a little paper published in the Journal of the Asiatic Society of Bengal for 1862 (vol. xxxi., pp. 49 seq.), has shown that the assigned position of the solstices indicates rather the twelfth than the fourteenth century B.C. as the time when the observation was made (the particular year, as determined by him, is 1181 B.C.). Prof. Max Müller, in his Preface to the fourth volume of his Ṛig Veda (London, 1862), adopts this rectified date, and then proceeds to point out the impossibility of so attaching the observation in question to any era or period in Hindu literary history as to make it chronologically available; also urging that the difficulty of the observation, and the unskilfulness of the Hindus as observers, compel us to leave a margin of several centuries on either side, in settling the time of the observation itself. To these conclusions, of Archdeacon Pratt and of Prof. Müller, my own assent has already been publicly expressed (see Journ. of the Am. Oriental Society, vol. viii., pp. 83, 84). In now recurring to the subject, I do not wish to retract or modify that assent, but to explain more fully the grounds on which it is based, treating of one or two points of interest, connected with the subject, which have hitherto been either not at all, or only imperfectly, elucidated.[1]

In the first place, I would say a few words in criticism of Archdeacon Pratt's calculation. He founds his conclusion, as concerns the fundamental point of the limits of the asterisms, upon the position, as observed by the Hindus and recorded in the modern astronomical text-books, of a single one of the junction-stars of the asterisms, namely, the brilliant α Leonis, or Regulus. That is to say, he determines the final point of Âçleshâ, which is also the initial point of Maghâ, solely from the statement made by the later Hindu astronomers, that Regulus is situated nine degrees upon the ecliptic east of the point in question. This star was selected by him, undoubtedly, because it is a bright one, situated close to the ecliptic (according to the Hindus, upon it), and in the next asterism to that in which is the place of the summer solstice, as laid down in the Jyotisha. But the defined positions of all the junction-stars of the asterisms are affected with serious errors and incongruencies, as compared with one another and with the assigned initial point of the sphere. The extreme errors are, two and a half degrees in the one direction, and three degrees in the other; the difference between them is five and a half degrees, which represents a difference of nearly five hundred years in the value of the precession as deduced, according to the method followed by Archdeacon Pratt, from the two junction-stars exhibiting the errors referred to.[1] In fact, had this gentleman founded his calculation upon the defined position of the junction-star of Pushya (the asterism lying next west, as Maghâ, with its junction-star Regulus, lies next east, of Âçleshâ), or of that of Chitrâ (as located by the Sûrya-Siddhânta), or of more than one other which might be chosen among the asterisms, he would have reached a result confirming, instead of overthrowing, Colebrooke's date. It was clearly, then, as I think, a mistake on his part to take Regulus alone into account, in performing his process intended for the testing and correcting of his predecessor's conclusions. If, indeed, Regulus could be shown to have been the star whose observation lay at the foundation of the Hindu system of asterismal division of the ecliptic, and by reference to which were determined the limits of the arcs constituting the "portions" of the asterisms, and the places of the other junction-stars, it would be fully entitled to be so distinguished by him; but it is unnecessary to say that such is not the case: there is no plausible ground for conjecturing, even, that this star was an especially prominent mark for the attention of the early Hindu astronomers. In our present ignorance as to the details of the process by which the observations upon the junction-stars were made, and their results reduced to the form in which they are presented to us by the Siddhântas, there are but two courses which we can safely follow: 1st, we may regard the assigned initial point of the system of division, the star ζ Piscium, as the actual starting-point of observation, and the varying errors of position of the other junction-stars as mere errors of observation committed with reference to that point,—in other words, accepting the limits of the asterismal portions as theoretically laid down in the Hindu text-books, and looking upon the places of the junction-stars in their respective portions as determined by the Hindus with what accuracy they were able to command;—or, 2nd, to average the errors of all the stars, and to modify by the result thus obtained the defined position of the initial point of division. Of these two, I should decidedly incline to prefer the former course. Following it, we find the difference between the solstice or the equinox of the Jyotisha and that of the modern astronomical system, which is the equinox of A.D. 560 (10′ east of ζ Piscium), to be one asterism and three quarters, or $(13^\circ\ 20' \times 1\frac{3}{4})$ $23^\circ\ 20'$; and this, at one degree of precession in seventy-two years,[1] gives an interval of $(23\frac{1}{3} \times 72)$ 1680 years, whence we should derive the date 1120 B.C. (1680—560 = 1120) as that of the observation recorded in the Jyotisha. If, on the other hand, we allow for the average of the Hindu errors of position (which, as is shown in the note on the table to which reference has already been made, is —56′), the result will be changed by sixty-seven years, and the date arrived at will be 1187 B.C. This last differs by but an insignificant amount from the date obtained by Archdeacon Pratt (1181 B.C.), nor does the other vary very materially from it; but this near accordance we must attribute to the good luck, rather than to the sound method, of the calculator: he chanced to select one of the junction-stars whose error of defined position (—49′) was small, and, moreover, very nearly coincided with the average error of the whole series.

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[1] There is the more reason for arguing the case anew, as, in a criticism of Dr. Haug's Aitareya Brâhmaṇam (in the *Saturday Review* for March 19, 1864) which is understood to come from the pen of Prof. Müller, this scholar seems inclined to abandon in part his former opinions, in deference to the authority of the writer whom he is criticizing; he says: "he is right also when he assigns the twelfth century as the earliest date for the origin of that simple astronomical system on which the calendar of the Vedic festivals is founded." The "margin of several centuries" here disappears, and the date of the observation becomes ascertainable with exactness.

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[1] Namely, those of Viçâkhâ and Chitrâ. For the amount and direction of the errors of position of all the junction-stars, see the table in our notes on the Sûrya-Siddhânta, in the Journ. Am. Oriental Society, vol. vi., p. 355 (p. 211 of the separate impression).

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[1] This is the rate adopted by Archdeacon Pratt in his calculation, and it is quite sufficiently exact. The Rev. R. Main, in a note to Müller's Preface (p. lxxxiv.), already referred to, substitutes a more precise valuation, and makes a difference of five years in the result; a totally insignificant correction in a calculation of this character.

Our next inquiry is: if the true date thus derivable from the Jyotisha is the twelfth century B.C.—its early part, according to one mode of reckoning; its later part, according to that to which the preference has been given above—how should so sound and careful an investigator as Colebrooke have come to pronounce it the fourteenth century? Archdeacon Pratt conjectures that he may have "taken the constellations loosely;" that is, as he explains himself, that Colebrooke may have based his calculations, in some way, not on the asterismal "portions," as equally divided, but upon the asterismal star-groups; taking the "beginning of Dhanishṭhâ" to be the first star in the asterism Dhanishṭhâ, not the first degree of the arc of 13° 20′ called Dhanishṭhâ, and the middle of Âçleshâ to be, not the centre of the arc of that name, but the middle of the little group in the head of Hydra, which, being called Âçleshâ, gave its name to the adjacent portion of the ecliptic. But he abandons the conjecture, as affording no sufficient explanation: and very properly, in my opinion, since I cannot think it possible that Colebrooke should have founded his calculation upon such an understanding of the language of the Jyotisha. Müller, on the other hand (Preface, p. xxvi.), appears to suppose that Colebrooke's statement is but an echo of that made by Wilford, on the authority of Davis, in the fifth volume of the Asiatic Researches (p. 288), to the effect that the date intended was 1391 B.C.[1] I cannot, however, think it likely that Colebrooke would thus have rested on a published opinion of another investigator without at least referring to it; nor, indeed, that he would have decided so capital a point without independent investigation: above all, when two scholars, of the rank and consideration of Jones and Davis, had arrived at conclusions respecting it which differed by more than two centuries. It is vastly more probable that Colebrooke shared Davis's error, whatever it may have been; that he either knew and approved the latter's calculation, or had of himself arrived, from like premisses and by a like course of mathematical reasoning, at the same result. No other scholars of that period have rendered to the study of Hindu astronomy services which can bear any comparison with those of Davis and Colebrooke; and an error in which they both agree ought to admit of an explanation which shall prove it to be no blunder, but only a deduction from a different, and an admissible, interpretation of the data furnished us from Indian antiquity.

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[1] Wilford's statement is put forth in correction of that of Sir William Jones, who had fixed the date at 1181 B.C. This seems a remarkable concordance with Archdeacon Pratt's result; but, in fact, the coincidence is only fortuitous: the real agreement of Jones's process is with my own. The amount of precessional movement, 23° 20′, and the derived interval of time, 1680 years, are the same in his calculation and in mine: but he reckons the interval back from an assumed period of Varâha-mihira, A.D. 499, and I, from the time when the equinox was actually 10′ east of ζ Piscium, or A.D. 560.

The only practicable method, so far as I can see, of arriving at the date given by Colebrooke and Davis, is to reckon the difference of precession between the Jyotisha and the modern astronomical system as two full asterisms, or 26° 40′. This, at 1° in seventy-two years, would give an interval of 1920 years, and would carry the Jyotisha observation back to beyond the middle of the fourteenth century B.C. (1920—560 = 1360 B.C.).[1] This would be the true date for that arrangement of the asterisms in which Kṛttikâ stands at their head—if only we suppose that the limits of the asterismal divisions were then precisely the same as they are determined to be in the later system of the Siddhântas, with Aṣwinî at the head. In the Jyotisha, as in all the other documents of the more ancient Hindu astronomy, Kṛttikâ is treated as first asterism; that is to say—so all are agreed in understanding it—as containing the vernal equinox. But the position of the solstices given in the Jyotisha implies, if taken exactly, an equinox no longer situated in Kṛttikâ, but fallen back even from its western limit, through the eastern quarter of Bharaṇi; thus giving to the latter the quality of equinoctial asterism, and the title to headship of the series. It might well enough, then, appear to Colebrooke that this seeming inconsistency of the Jyotisha with itself could be best solved by still regarding Kṛttikâ as equinoctial asterism, and supposing that the Jyotisha was only talking loosely in fixing the solstices at the beginning of Dhanishṭhâ and the middle of Âçleshâ, instead of at the end of the first quarter of Dhanishṭhâ and the third quarter of Âçleshâ. And, in my view, as I shall presently explain, he was fully justified in making this assumption. That he thus departed from the precise letter of the Jyotisha, and in a manner which ought properly to have been pointed out and accounted for by him, is very true; and it is greatly to be regretted that he did not enter into some brief explanation of his process of calculation. But he must be fully acquitted of the charge of having committed any real misrepresentation of his authority, by the date which he gave.

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[1] Davis's date, 1391 B.C., differs from this only to an insignificant amount, which may possibly be explained by supposing that he reckoned the precession at 1° in seventy-three years: its rate is, indeed, a little slower than 1° in seventy-two years, although the latter value is a good deal more nearly correct than the former.

It is, of course, theoretically supposable that the Hindus should have had an exact determination of the stellar place of the vernal equinox in the fourteenth century before Christ, and should have fixed by it the western limit of the asterismal portion Kṛttikâ; and that, some two centuries and a half later, they should have observed that it had fallen back through a quarter of the preceding asterism, and have recorded this observation in the Jyotisha. But no such supposition will possess the least plausibility to the mind of any one who is conversant with Hindu antiquity. The ancient astronomy of India was, evidently, of a very rude character. It had neither the instruments nor the theoretical system of division of the circle necessarily implied by exact measurements. It knew no lesser parts of the ecliptic than the twenty-sevenths, or "portions" of the asterisms. Its observations were only such as could be made with the unassisted eye, and were almost wholly limited to the moon, in her relations to the star-groups constituting the asterismal system. The lesser planets were altogether ignored. The ancient Hindus had devised no practical method of so reconciling solar and lunar time as to establish a year capable of continuous chronological use. The Jyotisha, by its cycle of five years and its mode of intercalation, assumes a year of 366 days: an inaccuracy which, after but two or three repetitions of the cycle, would have thrown their whole lunar reckoning into utter confusion. He who should expect anything approaching to an exact solution of so difficult a problem as the determination of the stellar place of the equinox from such a science, and from a people never capable of exact observation, even when they had learned scientific astronomy from the Greeks—unable, five centuries after Christ, to find the ecliptic distance from ζ Piscium of visible fixed stars in the nearest constellations of Aries, Taurus, and Orion, without errors ranging from fifty minutes up to nearly three degrees —he who should expect this, I say, would be guilty of something nearly approaching a palpable absurdity. If the Hindus themselves, in the ancient period, made an observation on the place of the colures which would have been an accurate one in the year 1360 B.C., no one should venture to draw from it any more precise conclusion than that it was probably made somewhere between 1800 and 1000 B.C. That they had any idea of the precession; that they were, or even believed themselves to be, able to notice when the colures had changed their places westward by three and a third degrees, or a quarter of an asterism, I do not in the least believe. If, then, the author of the Jyotisha impliedly puts the vernal equinox at the end of the third quarter of Bharaṇî, I have no idea that he meant to reject the actual reckoning, which implied its presence at the beginning of Kṛttikâ. If he had begun his year and his cycle with the vernal equinox, instead of the hibernal solstice, he would have put the equinoctial colure at the beginning of Kṛttikâ and the middle of Viṣâkhâ. His apparent shifting of its position has no deeper ground than this: that he did not care to talk in so exact terms as quarters of an asterism, and preferred to start from the beginning of an asterism, rather than from somewhere in its interior.[1] Colebrooke and Davis, therefore, if less faithful to the letter of the Jyotisha than Archdeacon Pratt, are equally true to its real meaning.

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[1] Weber, in his Jyotisha (Transactions of the Berlin Academy for 1862, p. 28), if I rightly apprehend his meaning, also inclines to this view.

A further element of doubt, however, requires to be taken into account, if we would fully appreciate the difficulties which lie in the way of our extracting a definite date from the passage of the Jyotisha now under consideration. In the later astronomical science of India, which has borrowed from abroad complete and elaborate modes of dividing the circle, of calculating the places of the planets, and so on, and which has made a real scientific determination, though an inexact one, of the places of the junction-stars of the asterismal groups, there is a precise theoretic division of the ecliptic into twenty-seven equal arcs, of thirteen and a third degrees (13° 20′) each, as "portions" of the twenty-seven asterisms. The starting-point is at, or close upon, ζ Piscium; and we know exactly how many degrees and minutes from that star lie the eastern and western limits of any given asterismal portion; as, also, by how many degrees and minutes the limits of each portion are distant from its own junction-star. It is true that the Hindu science does not recognize the necessity, or the propriety, of habitual reference to these limits in observation: they are there only for the benefit of the theoretic calculator; and the most practised Hindu astronomer, at any period, would doubtless have made lame work of pointing out their position with accuracy, or determining by observation the place of a planet with reference to them; yet they are a recognized part of the system. Now, in all our reasonings hitherto, we have assumed that the limits thus laid down by the modern science were also known to and adopted by the ancient. It was necessary to do so, if we were to find any ground on which to construct an exact astronomical calculation. But it is time to point out the total fallacy of the assumption. We have no reason whatever to believe that, when Kṛttikâ headed the series of asterisms, the junction-star of Revatî, ζ Piscium (even supposing the same star to have filled that office then as later, which there is room to doubt),[1] was the point of departure of the whole system of ecliptic division. We have no reason to believe that there was any system of division at all, founded on accurate measurements, and starting from a single definite point. The portion Kṛttikâ was not an arc of the ecliptic whose western and eastern boundaries were so many degrees and minutes distant from some fixed star, but simply that part of the moon's path which lay adjacent to the asterism or constellation Kṛttikâ (the Pleiades); the portion Âçleshâ was that on which bordered the constellation Âçleshâ (head of Hydra); and so on. To transfer to the ancient period the precise theoretic divisions of the later science, and to hold that, a thousand years before Christ, the phrases, "beginning of Kṛttikâ," "middle of Âçleshâ," "end of third quarter of Bharaṇî," and the like, designated the same points on the ecliptic as they do when employed by Brahmagupta and the author of the Sûrya-Siddhânta, is to commit a palpable and very serious anachronism. It was not practicable, in selecting a series of star-groups to mark a twenty-seven-fold or twenty-eight-fold division of the ecliptic, always to pitch upon such as had a like position in the theoretic limits of the several portions which each was to occupy and name. If any one will take the trouble to mark off, upon a globe or chart,[1] regions of the zodiac, each having 13° 20′ of breadth, he will find that only in a small majority of the cases (sixteen out of twenty-seven) does the Hindu asterism lie fairly within the boundaries of the portion which in the modern system it designates: in the remaining cases, it either overlaps the boundary, or is wholly embraced within the limits of the next portion. There is nothing surprising in this, because the moon does not, like the sun, move through the zodiac upon a single track, and always at the same rate in the same part of the heavens; the region of her accelerated or retarded motion, and of her removal southward or northward from the ecliptic, shifts so rapidly, that no series of stars or star-groups, however carefully selected, could continuously mark her progress with any degree of exactness. All that the founders of the system could seek to accomplish was this: to choose the proper number of groups, sufficiently conspicuous to be easily recognized and remembered, situated not too far from the ecliptic, and as nearly equally distributed as was practicable; all means of accurately testing the degree to which this last desirable requisite was complied with being wanting. No scheme of asterismal limits, then, depending on and determined by a single fixed point, is necessarily or even plausibly to be assumed as forming a part of the ancient asterismal system. And, especially, no such scheme determined by the star ζ Piscium. That star had no prominent importance in the eyes of the Hindu astronomers, so far as we know, until its near coincidence with the equinox of the period of reconstruction of the Hindu astronomy, five centuries after Christ, occasioned its selection as the cardinal point in the movements of the planetary system. Moreover, if it be made the determinant of division, all the series of seven asterisms, from Ṣatabhishaj to Kṛttikâ, inclusive, are found to be situated[1] upon the extreme eastern limits of the portions which belong to them respectively. It would be a strange method, surely, to commence from the Kṛttikâs (Pleiades) a series of asterismal divisions, made by the eye alone, which should leave the portion marked by that group, and named from its lying entirely behind it, to the westward.

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[1] See Journal Am. Or. Soc., vol. viii., pp. 44-5.

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[1] For instance, upon the comparative asterismal chart given in the additional notes to our translation of the Sûrya-Siddhânta (Journ. Am. Or. Soc., vol. vi.)

The conclusion to which we seem necessarily led by the arguments and considerations here presented may be summed up as follows:—First, it is impossible for us to determine, more nearly than within a few degrees, what point upon the ecliptic is meant by any designation of its place with reference to the asterisms which is given us by Hindu authorities of older date than the establishment of the modern astronomical system; second, we have no reason for ascribing to the ancient Hindus any pretence to such exact knowledge or any attempt at such precision of statement, as should give real significance to an implied difference of a quarter of an asterism in the location of the colures by two different authorities; third, even if we chose to attribute intended precision to the statement of the Jyotisha, the difficulty of the observation, and the weakness of the Hindus as practical astronomers, would forbid us to suppose that they can have made other than a rude approximation to the true place of the solstices: and hence, finally, it is utterly in vain for us to attempt to assign a definite date to the observation here in question; a period of a thousand years is rather too little than too great to allow for all the enumerated sources of doubt and error. He who declares in favour of any one of the centuries between the eighth and the eighteenth before Christ, as the probable epoch of the Jyotisha observation, does so at his peril, and must be prepared to support his opinion by more pertinent arguments than have yet been brought forward in defence of such a claim.

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[1] That is to say, in longitude; which is evidently, upon the whole, the fairest method of regarding their position as estimated by the unaided eye.

The possibility that the observation which we have been discussing may require to be yet more totally divorced from connexion with any assignable period in Hindu literary history, as having been made elsewhere than in India itself, is worth a passing reference, although it does not require to be urged. Some recent authors have shown an unnecessary degree of sensitiveness to any suggestion of the importation of astronomical knowledge into India in early times. Such importation, of course, is not to be credited as a fact without satisfactory evidence; but it is also not to be rejected as a possibility upon insufficient *à priori* grounds. To Müller's erroneous assumption (Preface, p. xxxviii.), that "none of the sacrifices enjoined in the Brâhmaṇas could be conceived" without "the division of the heavens into twenty-seven sections," I have referred elsewhere (Journ. Am. Or. Soc., vol. viii., p. 74), claiming that, on the contrary, the concern of the *nakshatras* with these sacrifices is for the most part a matter of nomenclature merely. It is true, for instance, that one cannot obey an injunction to perform a certain sacrifice "on the first of Chaitra" without a system of asterisms: but the reason why such a sacrifice had been enjoined was not that the moon was to be full fifteen days later in the neighbourhood of Spica Virginis, rather than of some other star; the ceremony was established for a certain new moon of spring, to which the star only gives a name: it may, for aught we know, have been religiously observed long before the month got its present title. The asterism Chitrâ does not furnish the occasion of the sacrifice, immediately or mediately; it simply denominates the natural period at the beginning of which the sacrifice is to be performed. And so in other like cases. It is not, indeed, to be denied that the *nakshatras* have acquired a certain influence and importance of their own, as regards the seasons of sacrifice: their propitious or unpropitious character must be had in view in regulating some of its details; but all this, like the astrological influence of the signs of the zodiac, is only the natural secondary outgrowth of an institution originally intended for other purposes. To claim to settle the vexed and difficult question of the ultimate origin of the asterismal system, possessed in common by the Hindus, the Chinese, and the Arabs, by the simple consideration of its importance to the Hindu ceremonial, is wholly futile. Biot, by similar reasoning, arrives at the confident conclusion that the system must be indigenous to China: he finds it too thoroughly interwoven with the sacred and political institutions of that country to be able to conceive of its ever having been introduced from abroad. And special students of Arab antiquity, upon the same grounds, advance the same claim in behalf of Arabia. It is in each case prepossession which gives to this class of considerations a controlling importance: the question of origin, if it ever finds its satisfactory settlement, must be settled by arguments of another and more legitimate character.

But the learned and ingenious editor of the Aitareya Brâhmaṇa, Dr. Haug of Pûna, the latest author who has made the Jyotisha observation a cardinal element in his system of chronology for the Vedic period, commits the yet more serious error of maintaining that such an observation was an essential prerequisite to the formation of a calendar for the regulation of the Brahmanic sacrifices.[1] It is plain that he both exaggerates the regularity of the ancient Hindu calendar, and misapprehends the relation to it of a determination of the solstice's stellar position. If the sun shone with as mild a radiance as the moon, so that one could see from what points among the stars he turns back towards the equator, at the end of his northern and southern progresses, by simply going out and looking at the heavens, his presence at the solstice, as thus determined, might constitute a natural and facile definition of the beginning of the year. But to fix the place of an equinox or solstice in the starry heavens is far from being a matter of direct observation; it is a deduction, and one of no small complication and difficulty to a people unversed in astronomy and poorly provided with instruments, from observations of another character. To find the *time* of the solstice or equinox, by such means as the shadow of the gnomon, or as noticing the points on the horizon where the sun rises and sets, is the necessary first step; and it is of itself sufficient to regulate the calendar, without the least reference to what star, or what asterism, might be nearest the sun at the time; the latter is a point rather of curious scientific interest than of practical chronological consequence. We are as yet without satisfactory evidence that the ancient Hindus had worked out any method of reconciliation of solar and lunar time possessing sufficient accuracy to admit of continuous practical use. The Jyotisha, certainly, does not furnish such a one; nor do we know whether even its cycle is more than an individual and isolated attempt, never ratified by general adoption and application, to solve the problem with which it deals. The Hindus can hardly be claimed to have had a calendar until the epoch of their modern astronomy. They kept a correct lunar reckoning, by simple observation of the lunations, naming each from the asterism in or near which the moon was full during its continuance; they kept a rude solar reckoning, by observations of the seasons, of the longest and shortest days, and the like; but they did not perplex themselves by over-attachment to coarse and imperfect modes of establishing the relations of the two reckonings. They could fix accurately the lunar date of any event or ceremony; they could correctly determine an interval of years; without needing to know exactly how long each year was, on what day it began, and whether it was of twelve or of thirteen months. The *sattras*, or great sacrifices lasting through a whole year, and divided into two corresponding halves, representing the northern and southern progresses (*ayana*) of the sun, to which Dr. Haug appeals as proving accurate astronomical observation among the Hindus of the period of the Brâhmaṇas, and even as implying a determination of the place of the solstice like that recorded in the Jyotisha, appear to me to prove rather the contrary of the former, and to have nothing whatever to do with the latter. So careless were the Hindus of anything like close accordance between the halves of their *sattras* and the sun's progresses, that they made the regular moon of the *sattra*-year to be 360 days, and admitted its variation to years of 324, 351, 354, and 378 days; the time of the beginning of the great festival was not a fixed and determinate one; in fact, none of the directions given respecting it in the Brâhmaṇas and Sûtras in the least imply a scrupulous and scientific regard to astronomical considerations.[1] And it is perfectly evident that the priests might have adapted their sacrifices with any degree of exactness to the movements of the sun, while utterly regardless of his position in the lunar zodiac. If, by a skilful deduction from data actually within their reach, they had determined with some tolerable degree of accuracy the situation of the solstitial point in the ecliptic, it would have been of no service to them in regulating their calendar, because they could not ascertain when the sun occupied that point directly, but only through the medium of observations which would have given them the regulation they sought immediately, without reference to the sun's place among the asterisms. The Hindus, indeed, for aught that we know or have reason to believe to the contrary, continued to recognize the solstice as at the place mentioned in the Jyotisha, down to the epoch of the modern astronomy; and no one will pretend that the Jyotisha is not later by many centuries than the true epoch of the observation it contains.

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[1] See the Aitareya Brâhmaṇam, etc., by Martin Haug. Bombay: 1863. Vol. i., Introduction, pp. 42 *sq.*

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[1] See the details in the second of Weber's valuable articles on the *nakshatras*, in the Transactions of the Berlin Academy for 1861, pp. 282 *sq.*, 344 *sq.*

The failure of Dr. Haug, then, to found a Vedic chronology upon this observation is as much more signal than that of his predecessors, as the use which he has sought to make of it is more definite and confident.

Let me not be misunderstood as attributing to the Hindus special incapacity for astronomy, or special awkwardness in the management of their calendar. They did all that could be expected of them, with their means and their habits of mind, towards reconciling and adjusting the trying differences of solar and lunar time; and with all the success which was needful for their purposes. I am only protesting against the misconceptions of those who would ascribe to them wants and desires, and credit them with mechanical devices, in no way answering to their condition. To look for an exact observation of the place of the colures in a treatise which adopts a year of 366 days, and assumes and teaches the equable increase and decrease of the length of the day from solstice to solstice, is obviously in vain: to calculate a precise date from such an observation is but to repeat, in another form, the worst errors of Bailly and Bentley.

New Haven, Conn., U. S. A., June, 1864.